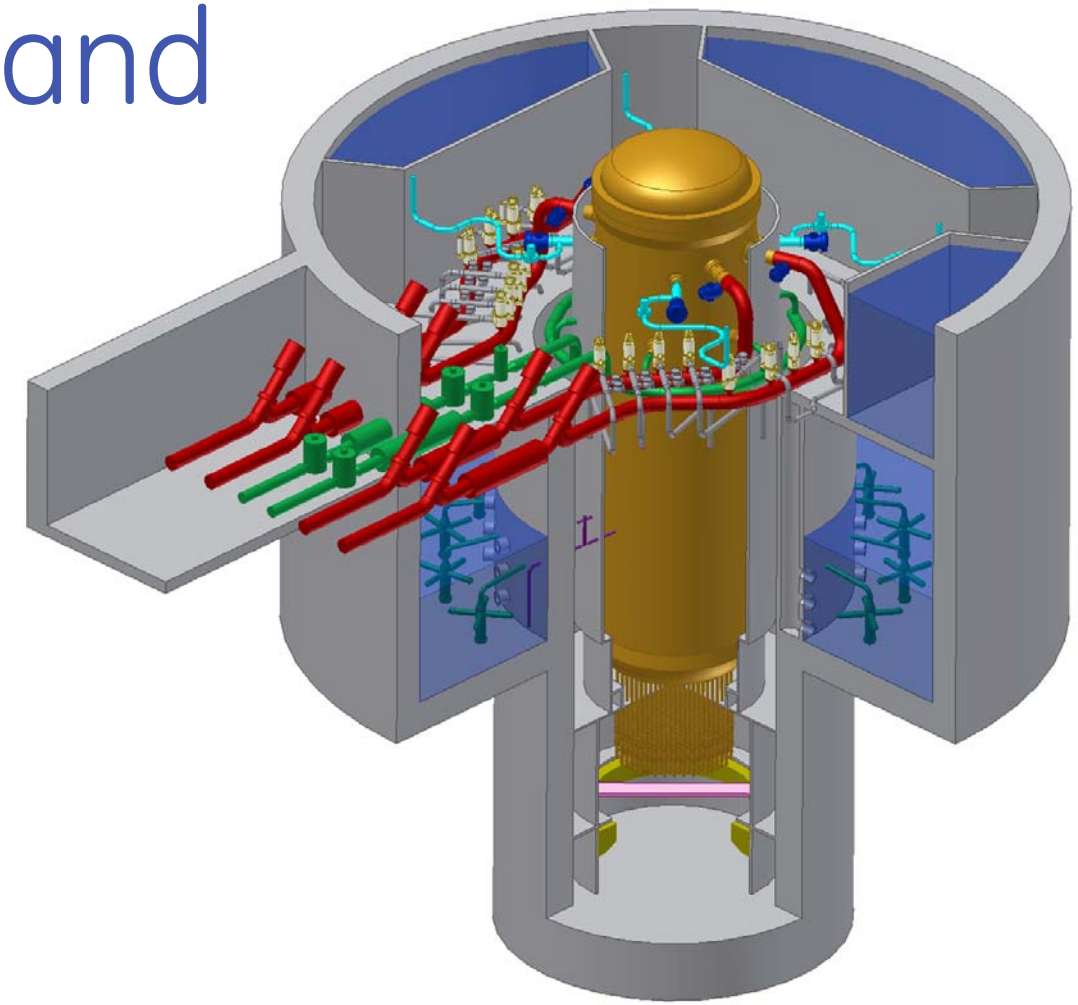
ESBWR Overview Nuclear Island Systems



J. Alan Beard

September 15, 2006

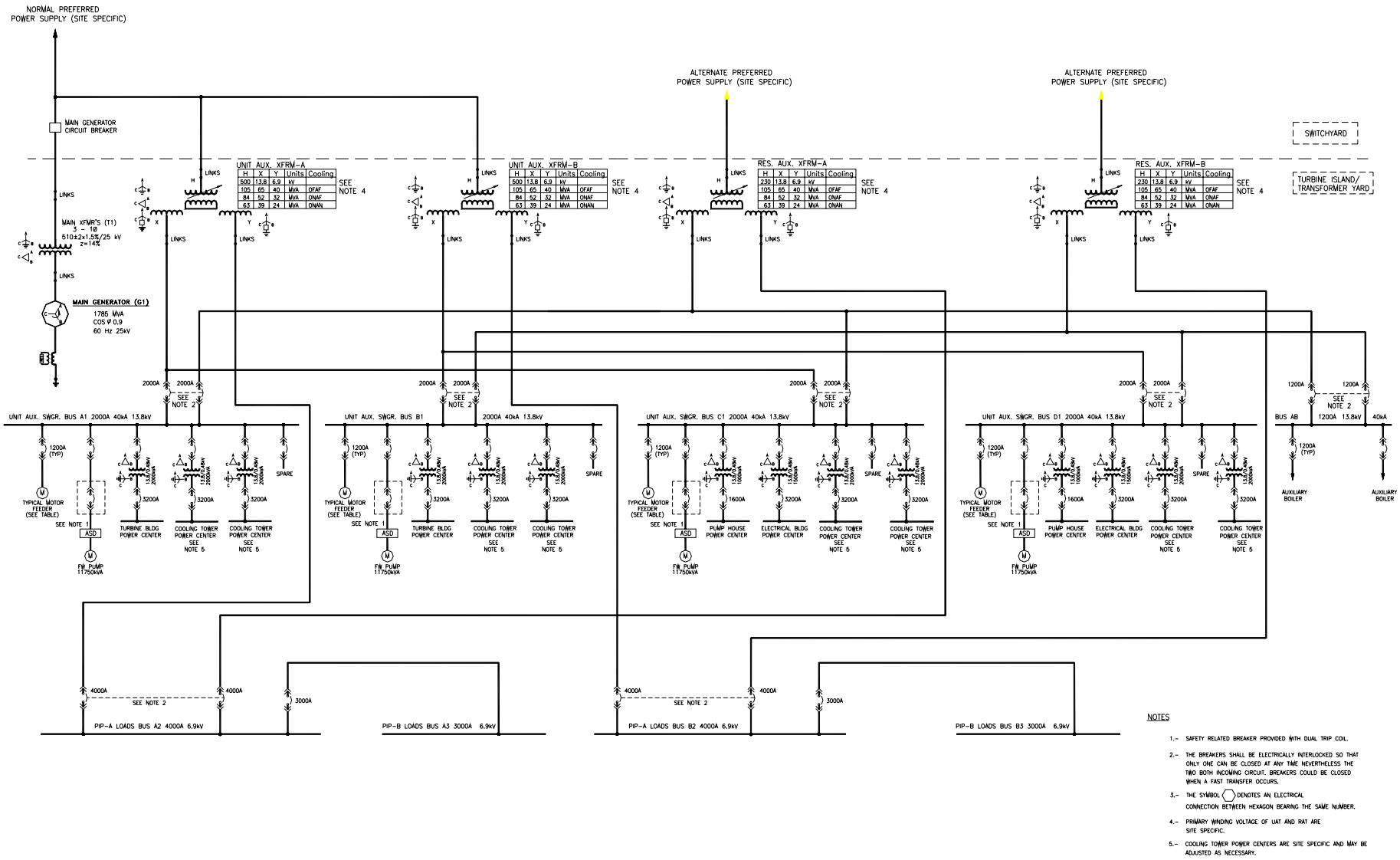
ESBWR Auxiliary Systems Overview

- Plant Investment Protection (PIP) Electrical
- Control Rod Hydraulics
- Fuel and Auxiliary Pools Cooling System
- New Fuel Storage
- Spent Fuel Storage
- Reactor Component Cooling Water System
- Chilled Water System
- Control Building HVAC System
- Drywell Cooling System
- Containment Inerting System
- Fire Protection System

Plant Investment Protection (PIP)

- Non-safety systems provide for defense in depth
  - Significant contributors to plant availability
  - Asset Protection
  - > On-Site AC Power (Diesel Generators)
    - > Electrical Distribution
  - > CRD Hydraulics
  - > Reactor Water Cleanup
  - > Fuel and Auxiliary Pool Cooling and Cleanup

Electrical Distribution



NOTES

1.- SAFETY RELATED BREAKER PROVIDED WITH DUAL TRIP COIL.

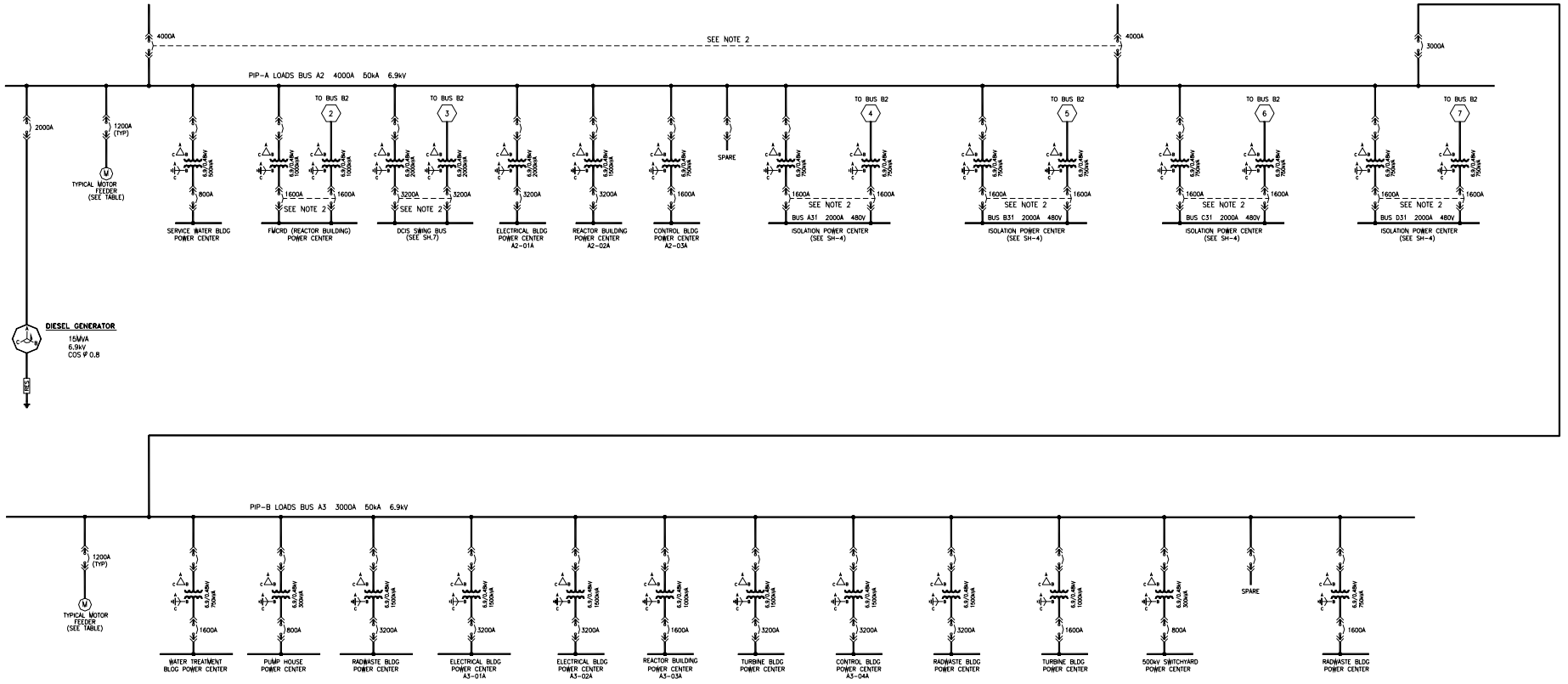
2.- THE BREAKERS SHALL BE ELECTRICALLY INTERLOCKED SO THAT ONLY ONE CAN BE CLOSED AT ANY TIME NEVERTHELESS THE TWO BOTH INCOMING CIRCUIT BREAKERS COULD BE CLOSED WHEN A FAST TRANSFER OCCURS.

3.- THE SYMBOL ⬡ DENOTES AN ELECTRICAL CONNECTION BETWEEN HEXAGON BEARING THE SAME NUMBER.

4.- PRIMARY WINDING VOLTAGE OF UAT AND RAT ARE SITE SPECIFIC.

5.- COOLING TOWER POWER CENTERS ARE SITE SPECIFIC AND MAY BE ADJUSTED AS NECESSARY.

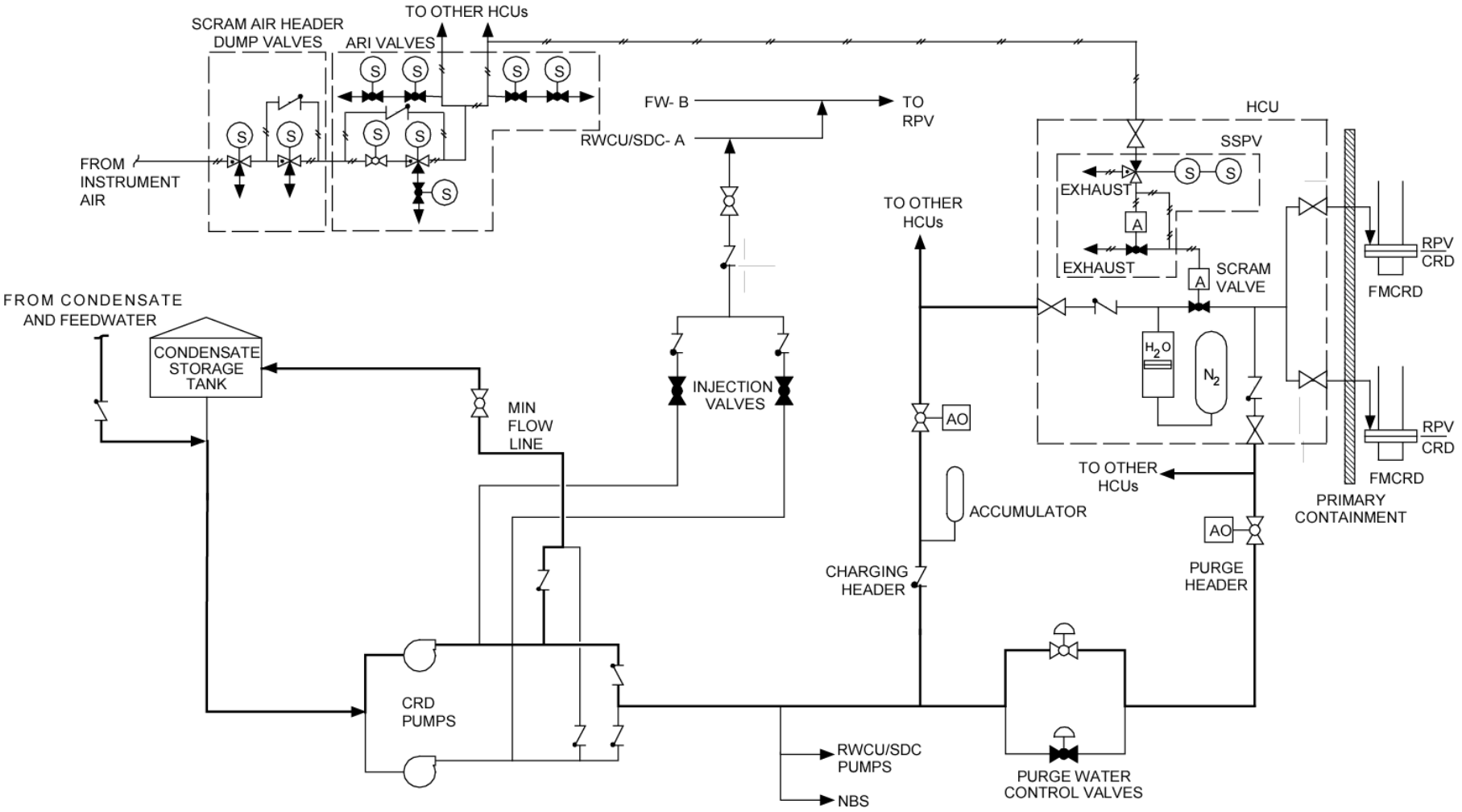
Plant Investment Protection Busses



Control Rod Drive Hydraulics

- Two High Pressure Trains
  - > Keep HCUs charged
  - > Cooling/Purge flow to CRDs and RWCU
  - > Reference Leg Purge (RPV Water Level)
  - > High Pressure Makeup
    - – ~515 gpm per pump at rated reactor pressure
    - – Beyond Design Basis Accident Mitigation

Control Rod Drive Hydraulics



FAPCS Operating Modes

- Normal Operating Modes
  - > Spent Fuel Pool Cleaning and Cleanup
  - > IC/PCCS Pool Cooling and Cleanup
  - > GDCS Pool Cooling and Cleanup
  - > Suppression Pool Cooling and Cleanup

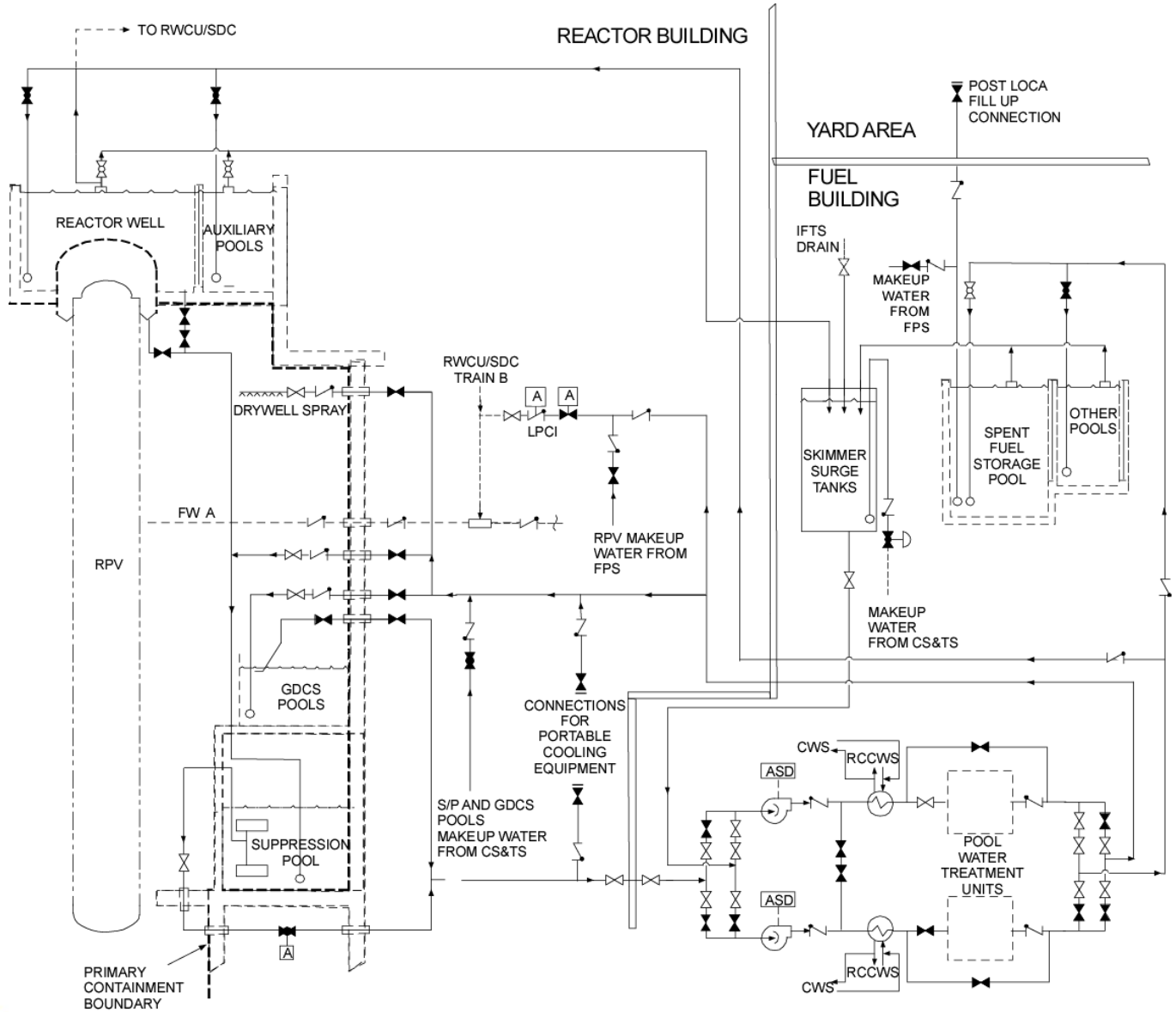
Pools Serviced by FAPCS

Pools Serviced by FAPCS C/C Subsystem	**Location**
Fuel Pools	Fuel Building
- Spent Fuel Pool	
- Lower Fuel Transfer Pool	
- Cask Pool	
- Cask Head Shelf Pool	
Auxiliary Pools	Reactor Building
- Steam Dryer and Seperator Storage Pool	
- Reactor Well	
- Buffer Pool	
- Upper Fuel Transfer Pool	
GDCS Pools (3)	Containment
Suppression Pool	Containment
Pools Serviced by IC/PCCS Pool C/C Subsystem	
IC/PCCS Pools	Reactor Building
Expansion (Outer) Pool	

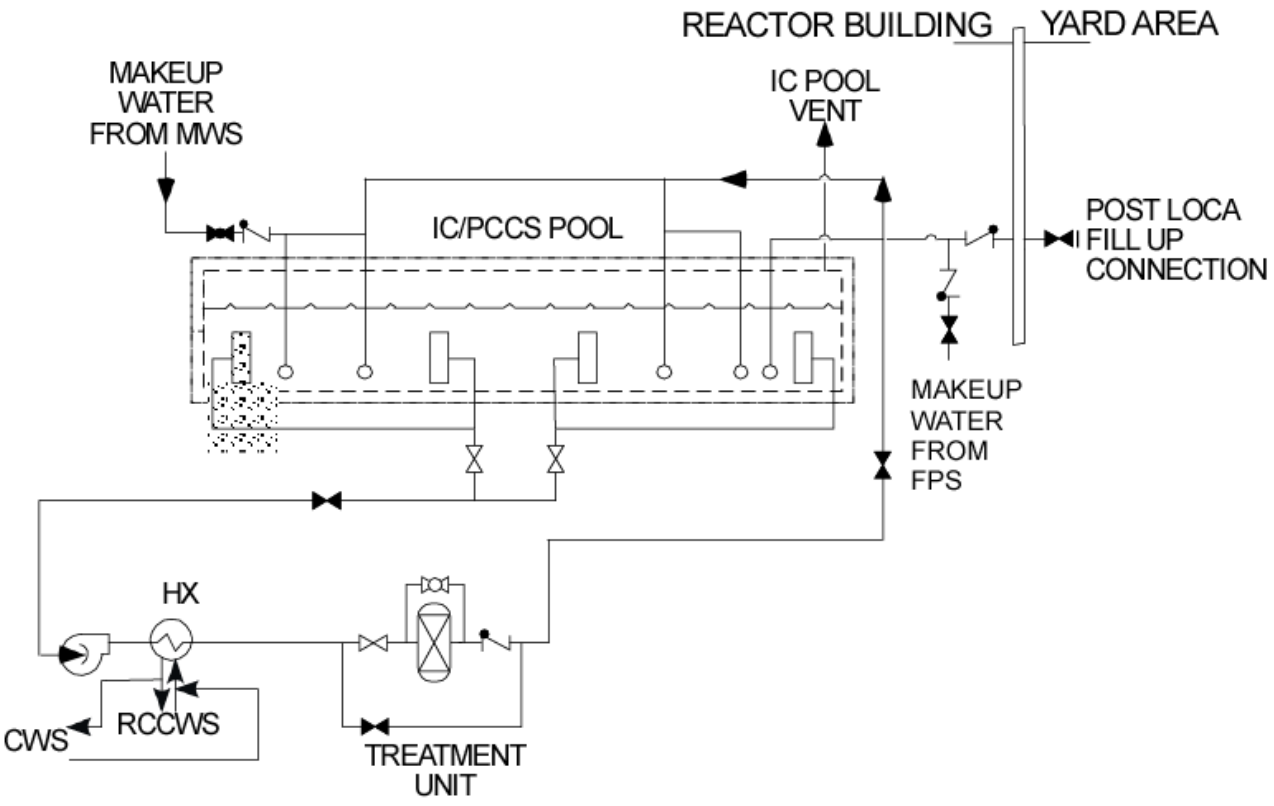
FAPCS - Available Post Accident Operating Modes

- FAPCS may be operated in the following modes for post-accident recovery following an accident:
- Spent Fuel Pool Cooling
- Low Pressure Coolant Injection (LPCI)
- Suppression Pool Cooling (SPC)
- Drywell Spray
- Alternate Shutdown Cooling (ASDC)
- FAPCS piping can also be used to provide makeup water to IC/PCCS pools and Spent Fuel Pool from offsite emergency water supply or Fire Protection system following a DBA

Fuel and Auxiliary Pool Cooling



Fuel and Auxiliary Pool Cooling



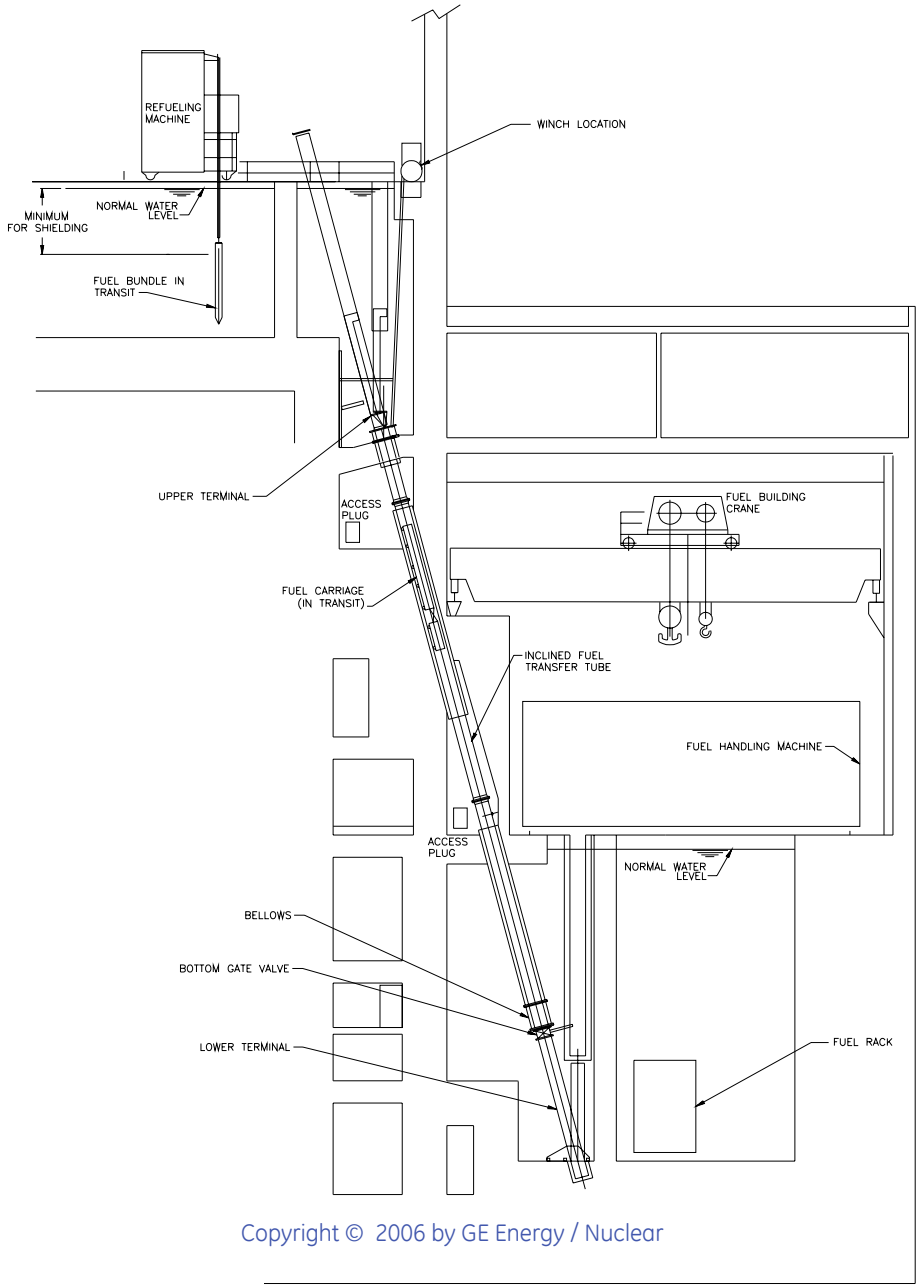
New Fuel Storage

- Located in the RB buffer pools on the Operating Floor
  - > Capacity for all new fuel assemblies for a 24 month cycle
  - > Racks are side loaded and have double rows of storage positions
  - > Racks are floor mounted
- Designed to ensure fully loaded array is subcritical by at least 5% $\Delta k/k$
- Designed to protect fuel assemblies/fuel bundles from damage for all credible events

Spent Fuel Storage

- Spent Fuel Storage Racks are top entry racks
- Designed to ensure fully loaded array is subcritical by at least 5% $\Delta k/k$
- Located in the spent fuel pool in the FB and RB
- Provides storage for 10 calendar years of plant operation plus a full core off load
- 154 bundles of spent fuel storage is available in the buffer pool to provide operational flexibility
- Spent Fuel Storage Pool has adequate water shielding over spent fuel
- On loss of FAPCS SFP cooling, sufficient water above spent fuel to allow boiling for 72 hrs and still have 3.0m
- Spent fuel is transferred from the RB Operating floor to the FB spent fuel pool via the Inclined Fuel Transfer Tube (IFTT)

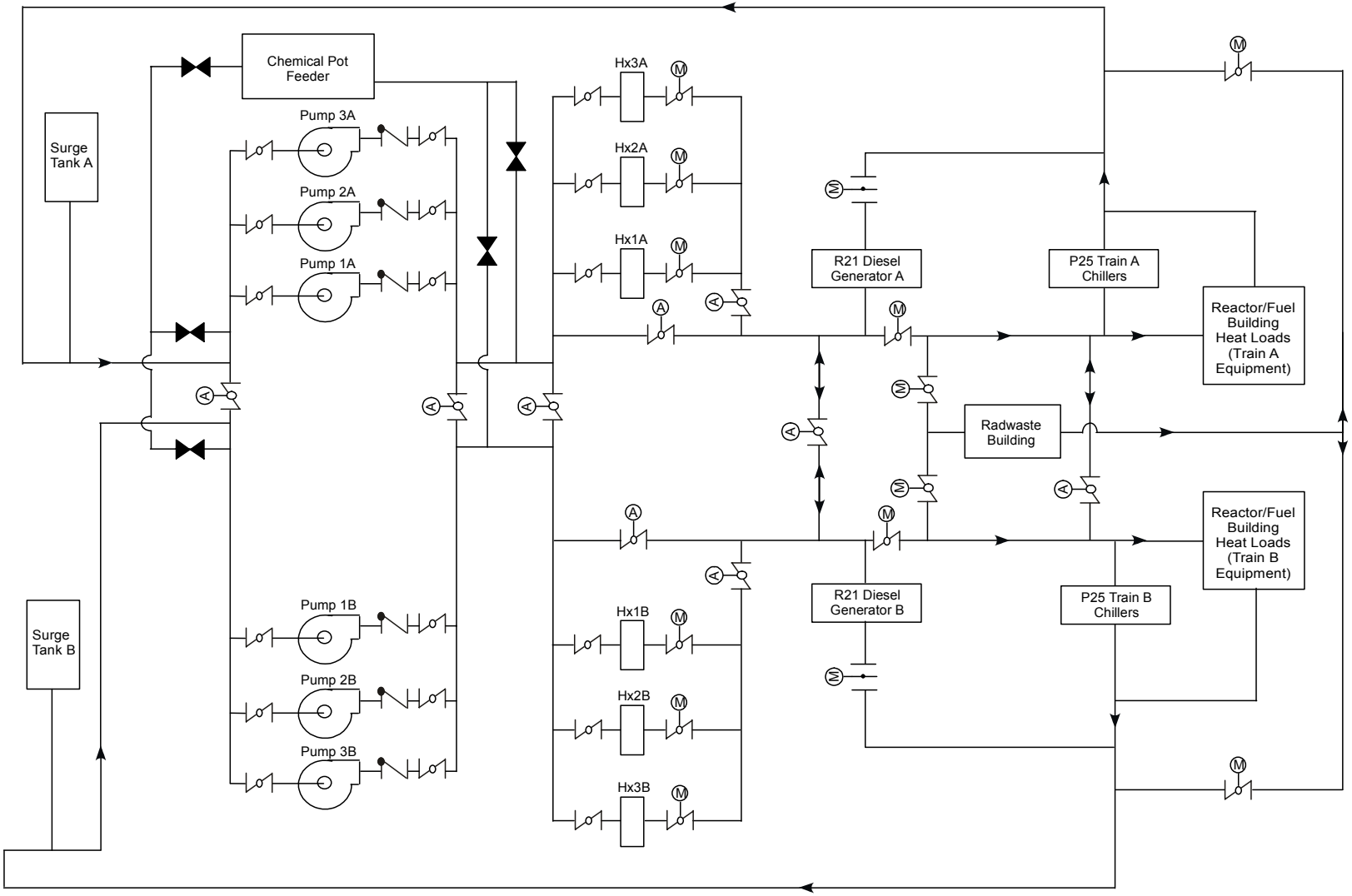
Inclined Fuel Transfer Tube (IFTT)



Reactor Component Cooling Water System

- System does not perform any safety-related function
- Provides cooling water to plant auxiliary equipment during normal operation, cooldown and shutdown operation
- No single active failure nor credible single passive component failure will result in loss of active nuclear island cooling
- System is powered from the PIP busses so that it operates during a LOPP
- Designed to limit leakage of radioactive components to the environment
- Consists of two 100% capacity independent and redundant trains

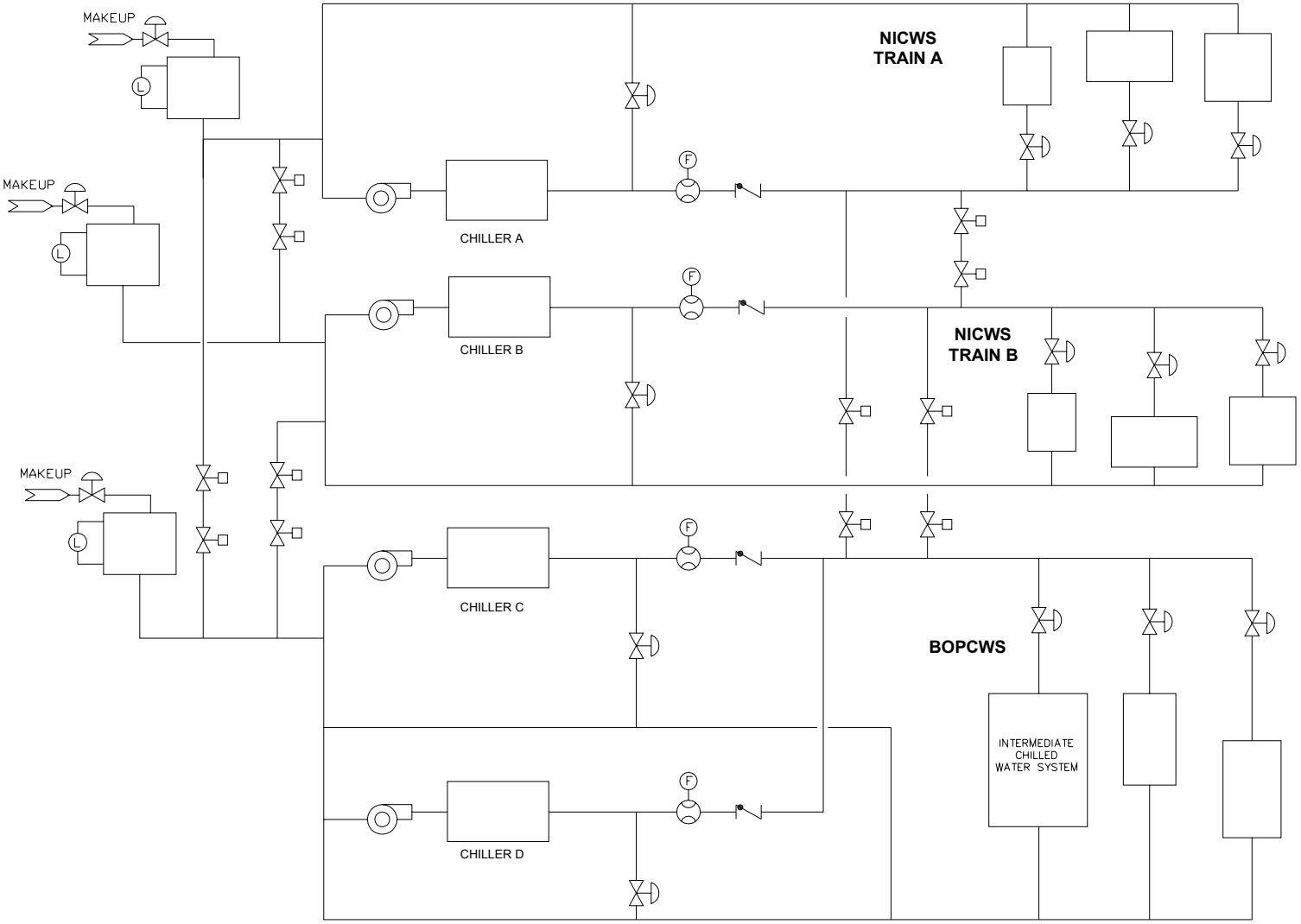
Reactor Component Cooling Water System



Chilled Water System

- CWS consists of Nuclear Island Chill Water Subsystem (NICWS) and Balance of Plant Chilled Water Subsystem (BOPCWS).
- Provides chilled water (7° C (44.6° F)) to plant equipment
- NICWS is powered from the PIP busses so that it operates during a LOPP.
- CWS is designed as Seismic Cat II criteria when located in Seismic Cat I buildings
- NICWS and BOPCWS are independent subsystems but interconnected
- Chilled water is provided to cooling coils of AHU's and other coolers in RB, CB, TB, RWB, SB, EB, FB, TSC and Hot Machine Shop
- NICWS provides chilled water to the Drywell Cooling System (T41) DW air coolers
- NICWS consists of two 100% capacity redundant and independent trains
- BOPCWS consists of one 100% capacity independent train with crossties to both NICWS trains

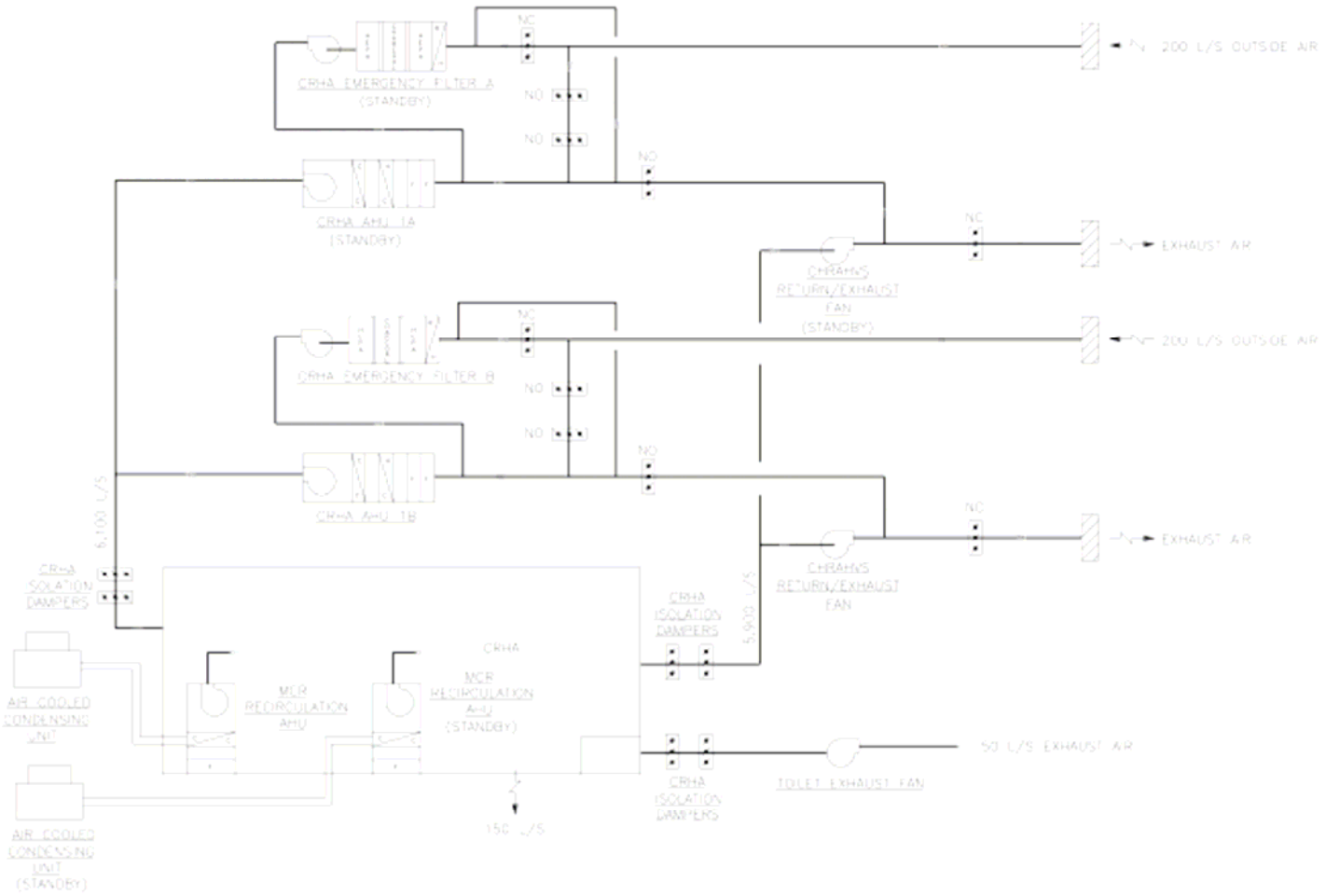
Chilled Water System



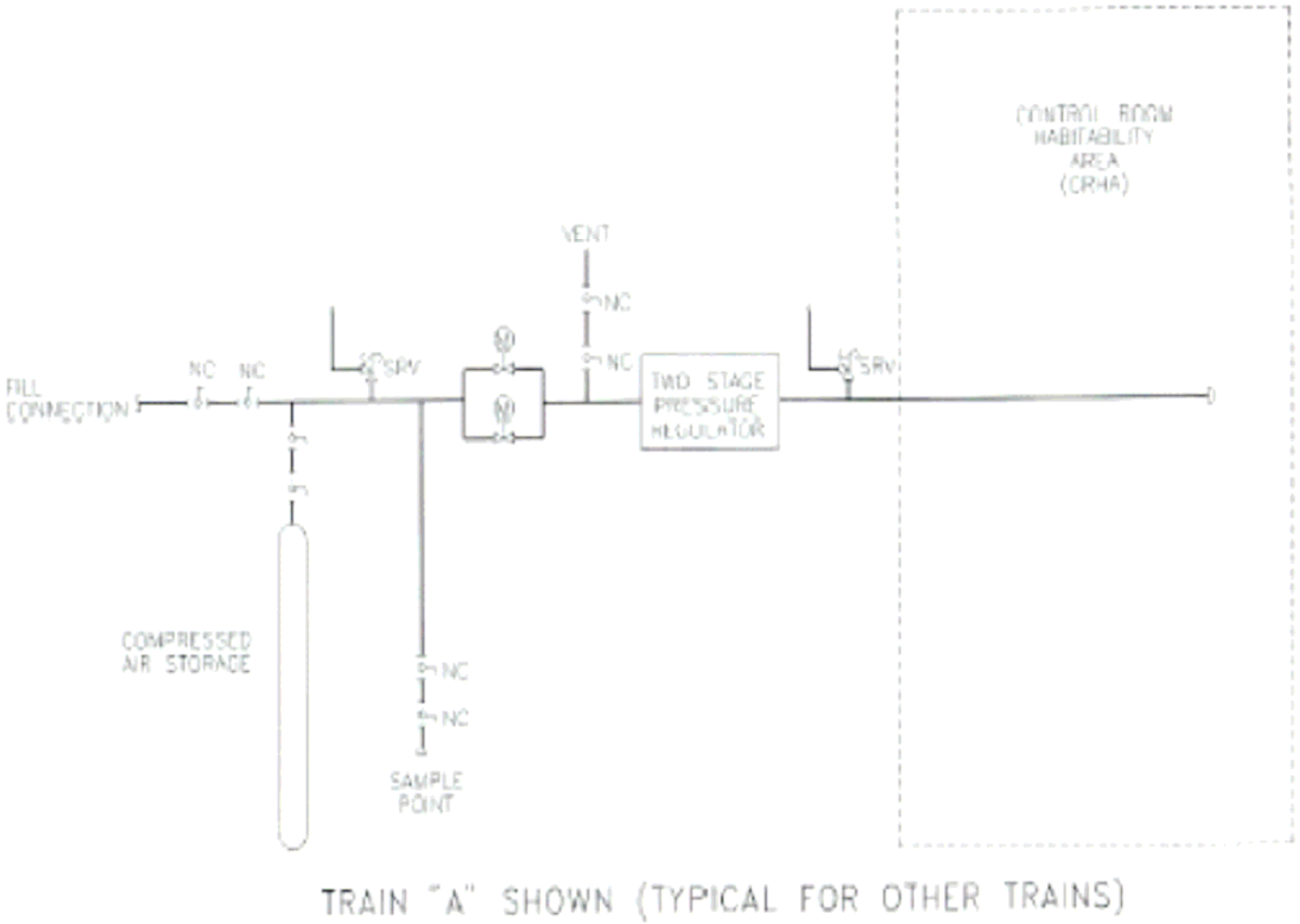
Control Building HVAC System

- Consists of three subsystems: CR Habitability Area HVAC Subsystem (CRHAHVS), Emergency Breathing Air System (EBAS)
- CRHAHVS serves the MCR and associated support areas
- EBAS provides pressurized bottled air to the Control Room Habitability Area (CRHA) during radiological events and in the event of a SBO.
- On detected high radiation or toxic gas the air inlet and exhaust dampers of CRHAHVS will close and MCR air is recirculated with no outside air makeup.
- An Emergency Filter Unit (EFU) with a HEPA filter and charcoal filters is available to serve the CRHA if power is available
- No single active failure can result in loss of system performance
- During SBO MCR temperature rise is only 8.3° C (15 ° F) after 72 hours

Control Building HVAC System



Emergency Breathing Air System (EBAS)

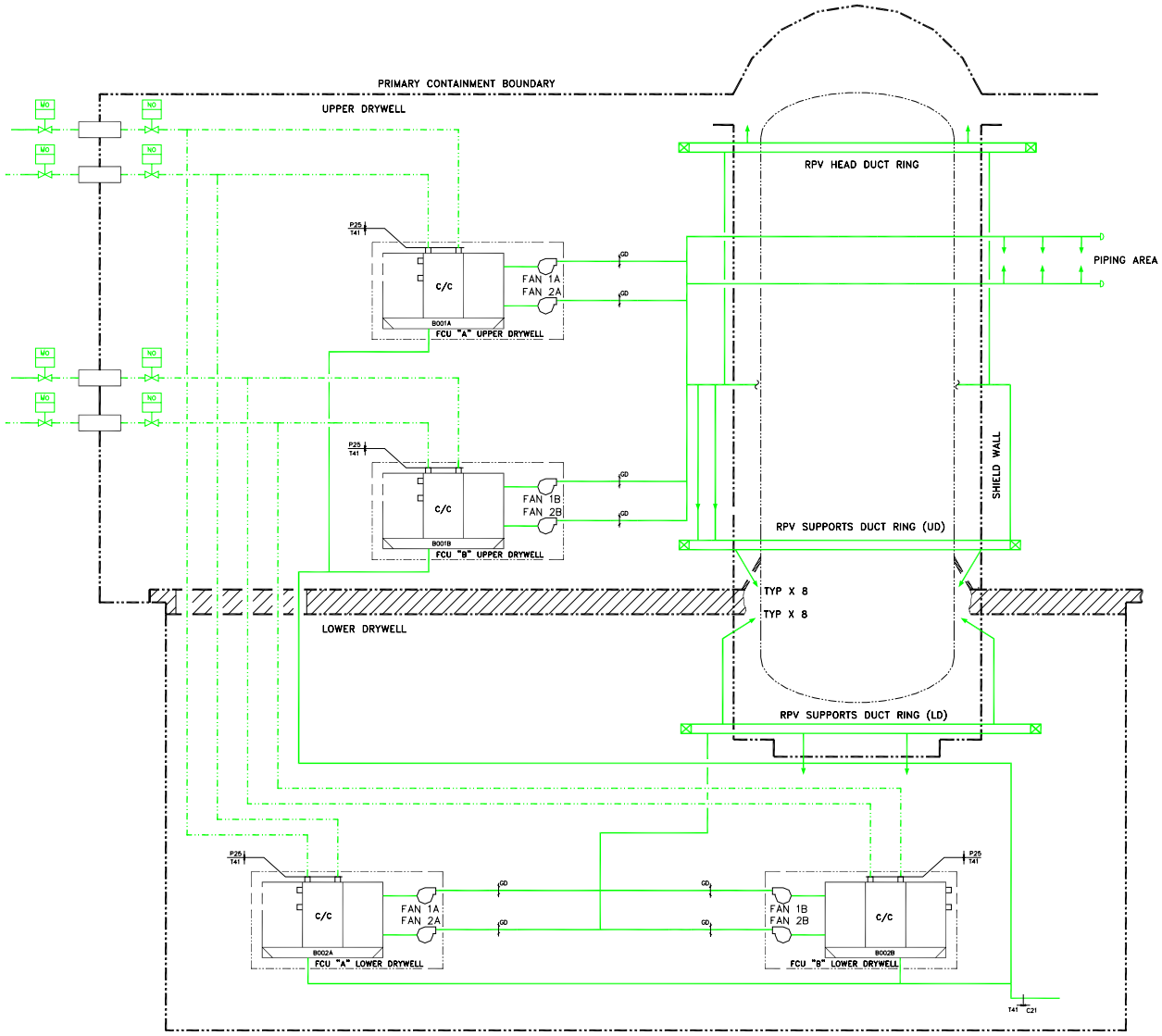


TRAIN "A" SHOWN (TYPICAL FOR OTHER TRAINS)

Drywell Cooling System (T41)

- DCS maintains upper and lower drywell temperatures within limits during normal operation, accelerates DW cool down going from hot to cold shutdown, assists in purging DW N_2 during shutdown, maintains DW environmental conditions during outages and limits DW temperatures during a LOPP
- DCS is a closed loop recirculation air/N_2 cooling system with no outside air/N_2 introduced
- Ducts distribute cooled, recirculated air/N_2 thru diffusers and nozzles
- DCS consists of four FCUs, two 50% capacity FCUs in the upper and two 50% capacity FCUs in the lower DW
- Each FCU consists of a cooling coil and two fans – only one is normally in operation the other is in standby
- Chilled Water System provides cooling water to the FCU cooling coils
- The DCS is powered off of the PIP busses

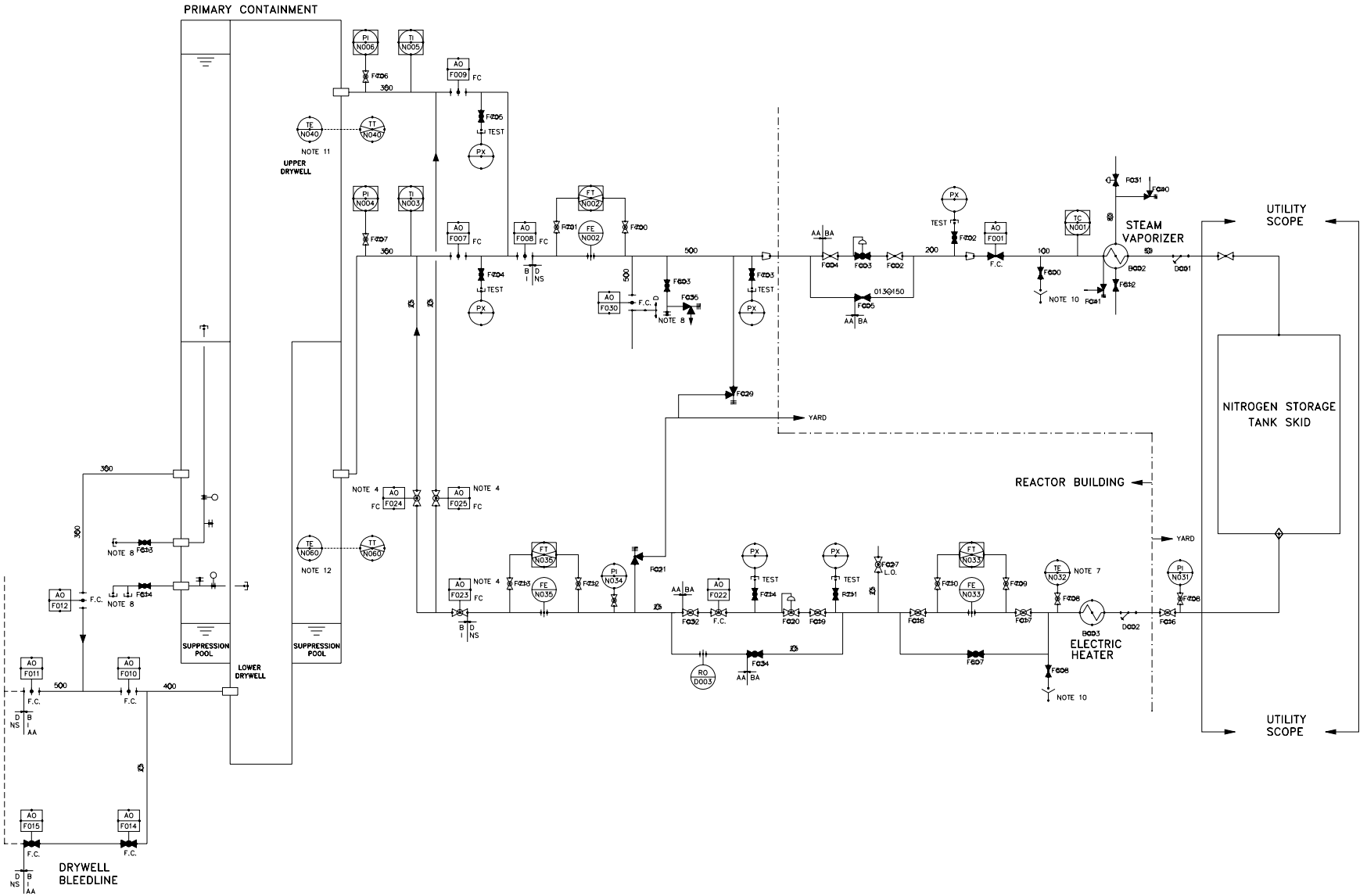
Drywell Cooling System



Containment Inerting System

- System is design to establish containment inerted atmosphere of < 4% O_2 by volume in < 4 hours and < 2% O_2 in the next 8 hrs.
- Maintains containment O_2 level < 3% during normal, abnormal and accident conditions.
- Maintains slight positive pressure during normal, abnormal and accident conditions to prevent air in-leakage.
- N_2 gas makeup supply has capacity to maintain + 4.8 kPaG (0.7psig) in containment.
- System has sufficient capacity to replenish 0.5 % RCCV volumes per day based on the containment operating pressure.
- CIS permits de-inerting the containment for safe access in < 12 hrs.
- CIS is design to relieve containment pressure during a severe accident before uncontrolled containment failure could occur.
  - > This operation is performed manually
  - > Function was previously performed by Containment Over Protection System

Containment Inerting System



Fire Protection System

- Fire Protection System is classified as a nonsafety-related system although it is subject to RTNSS requirements
- System is designed with defense in depth to achieve the required degree of reactor safety. System is designed to:
  - > Control the spread and extinguish fires in all plant areas using fixed and/or portable fire fighting equipment,
  - > Provide automatic fire detection and annunciation,
  - > Provide maximum firewater demand assuming a single failure,
  - > Preclude loss of function during a seismic event,
  - > Preclude loss of fire water supply - two separate and independent fire water sources are connected to FPS
  - > Ensure no single failure caused by an MELB can impair both the primary and backup fire suppression system
  - > Provide a source of on site makeup water to FAPCS for the IC/PCC pools 72 hrs after a LOCA for 7 days

Fire Protection System

- Fixed automatic Fire suppression systems are installed in areas having a high fire hazard rating
- Building standpipes and hose stations are provided in major buildings
- Portable fire extinguishers are strategically located throughout the plant
- Comprehensive fire detection, alarm, supervisory control, and indication provided thru out the plant
- Operation of system is automatic – can be locally controlled
- Main fire panel alarm panel is located in MCR
- Three 50% capacity firewater pumps provides 100% of demand assuming worst-case fire within NI
  - > Two NI fire pumps are located on top on a Seismic Cat I structure – lead pump is motor drive, backup pump is diesel driven
  - > The second diesel driven fire pump is located remotely from the NI fire pumps and provides backup
  - > Fuel oil tanks for diesel driven fire pumps has capacity for approximately 8 hrs

Fire Protection System